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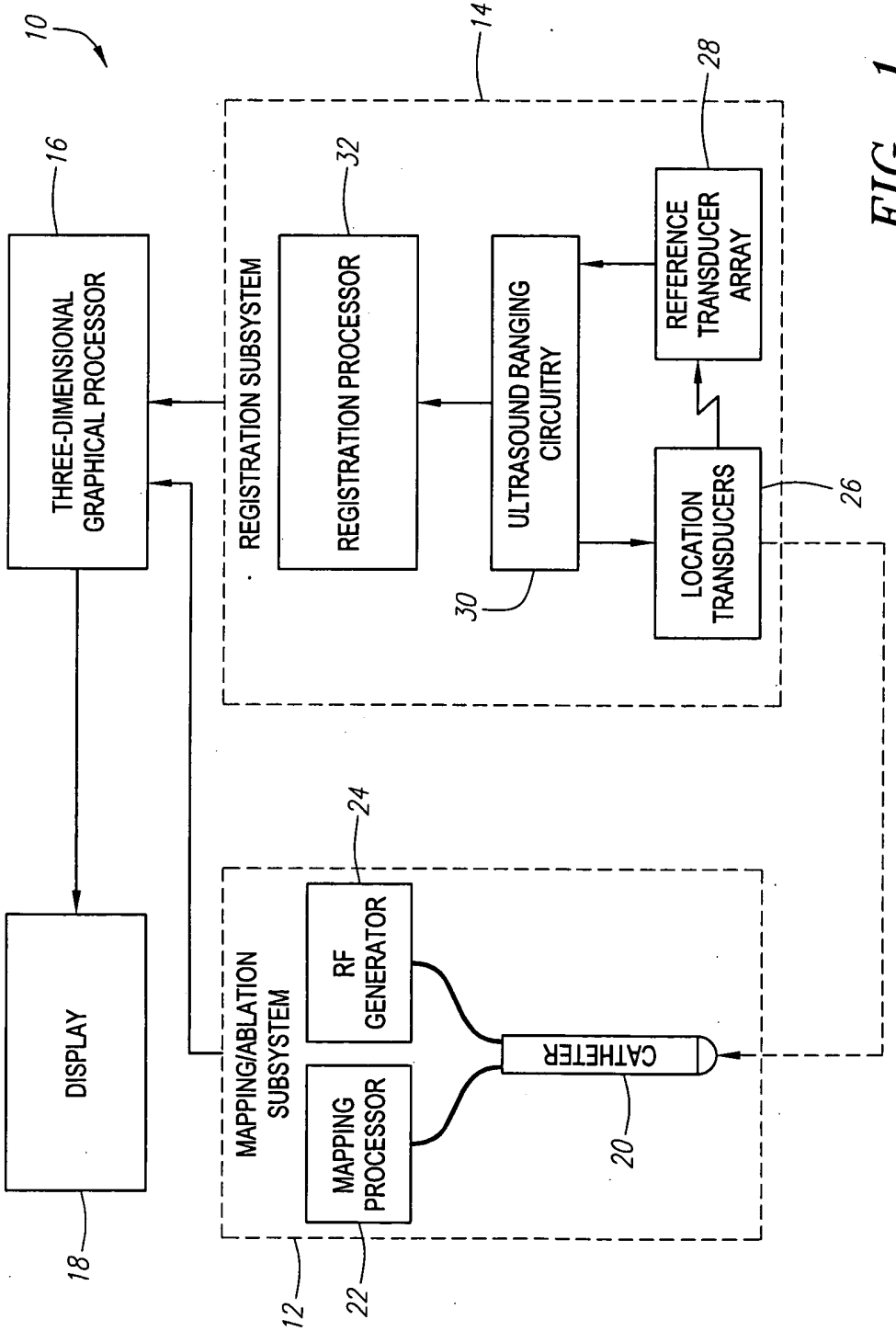


FIG. 1

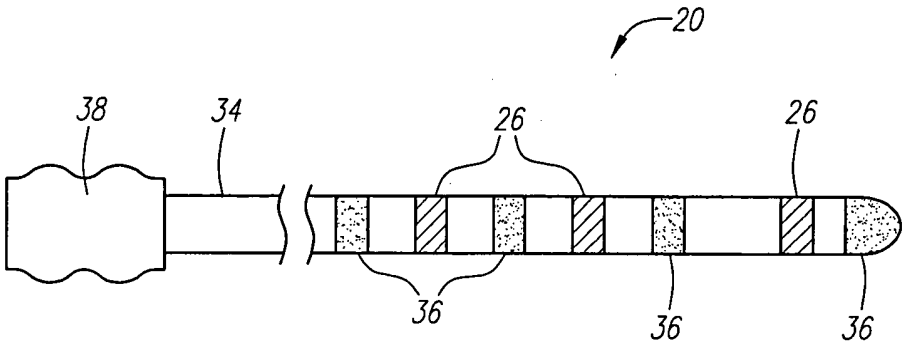


FIG. 2

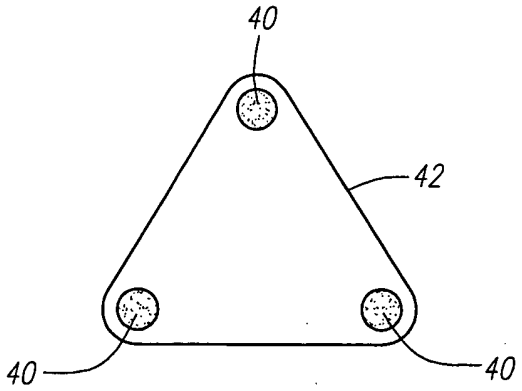


FIG. 3

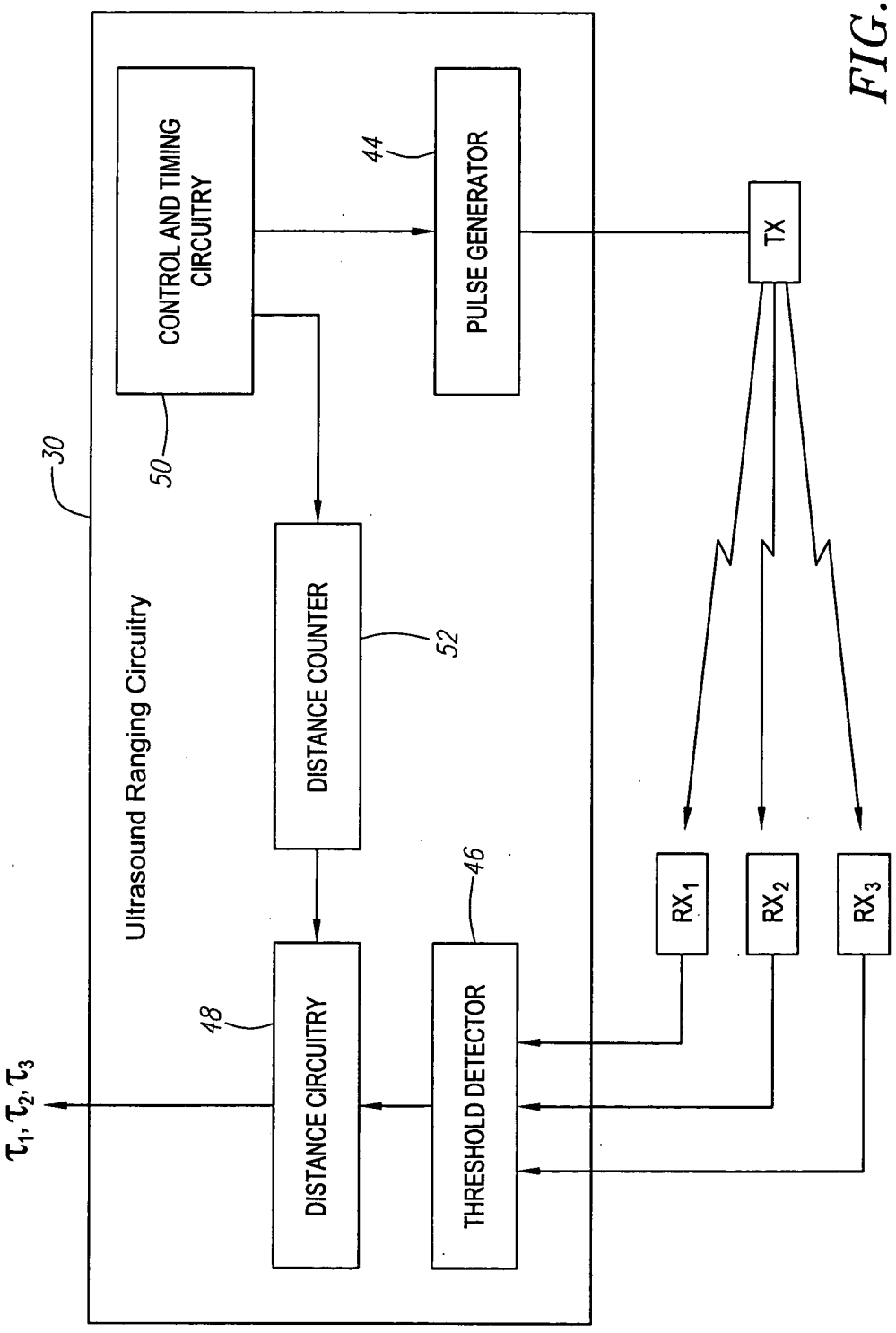

CONTROL AND TIMING CIRCUITRY
PULSE GENERATOR
TX
44
50
30
Ultrasound Ranging Circuitry
DISTANCE COUNTER
52
RX1
RX2
RX3
46
48
DISTANCE CIRCUITRY
THRESHOLD DETECTOR
τ1, τ2, τ3

FIG. 4

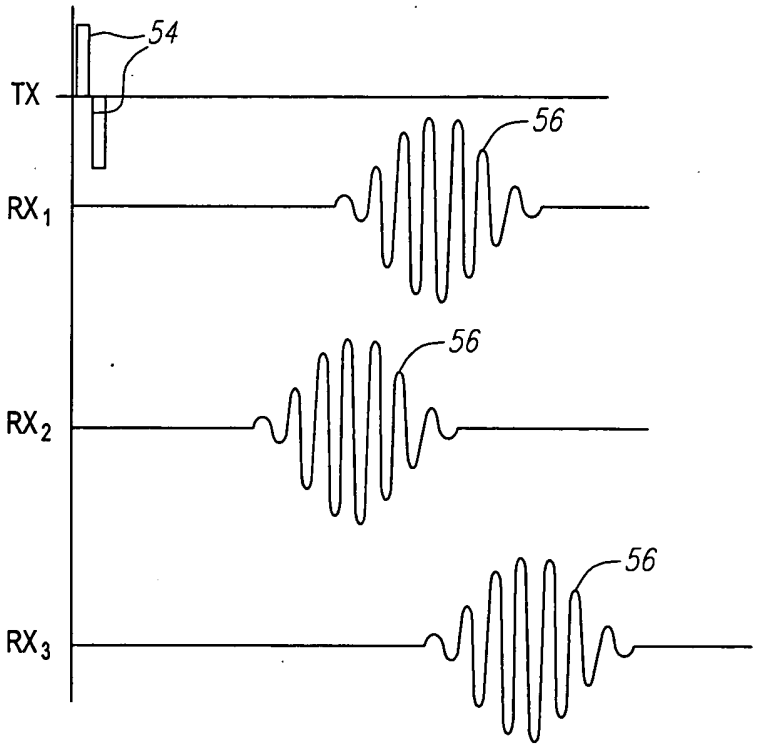
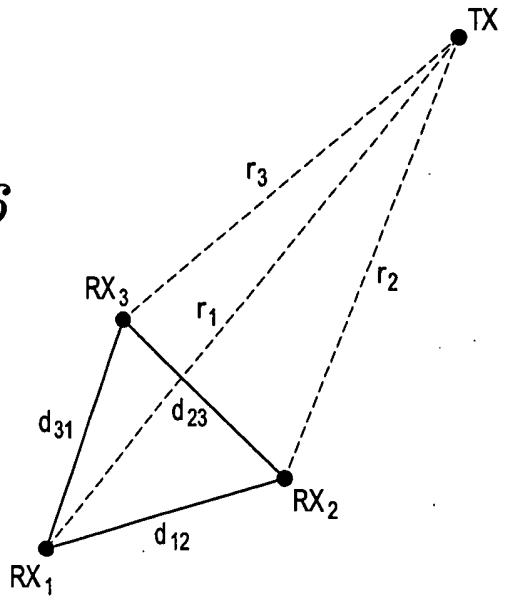


FIG. 5

FIG. 6



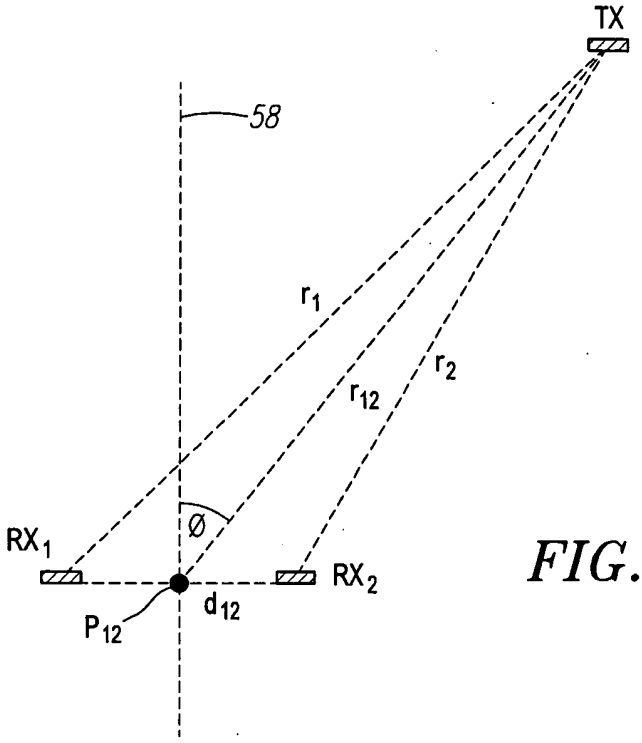


FIG. 7

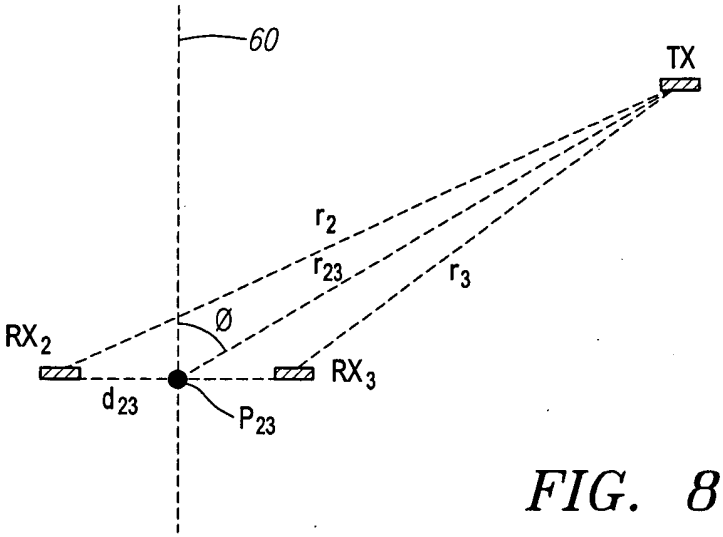


FIG. 8

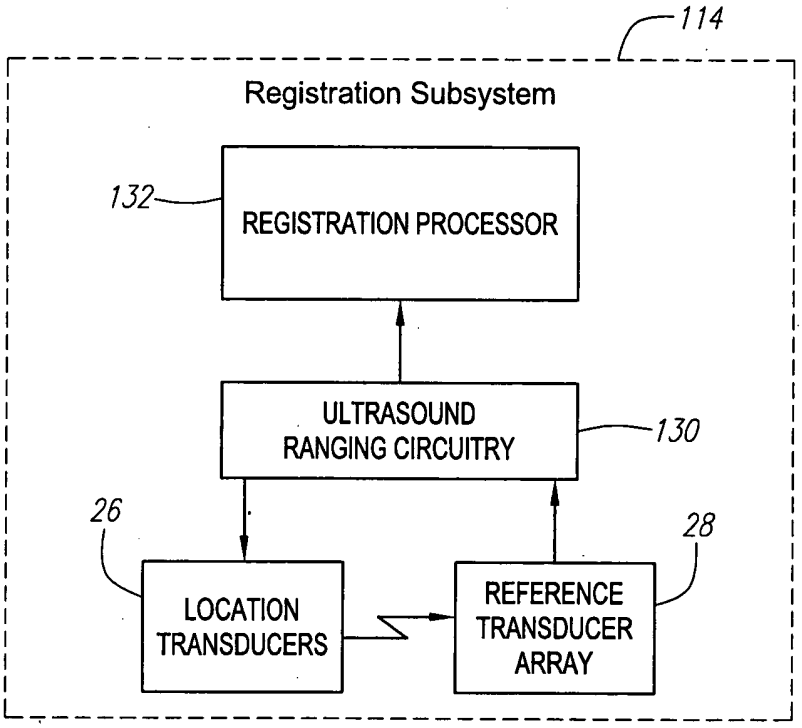

114
Registration Subsystem
132
REGISTRATION PROCESSOR
ULTRASOUND
RANGING CIRCUITRY
130
26
28
LOCATION
TRANSDUCERS
REFERENCE
TRANSDUCER
ARRAY

FIG. 9

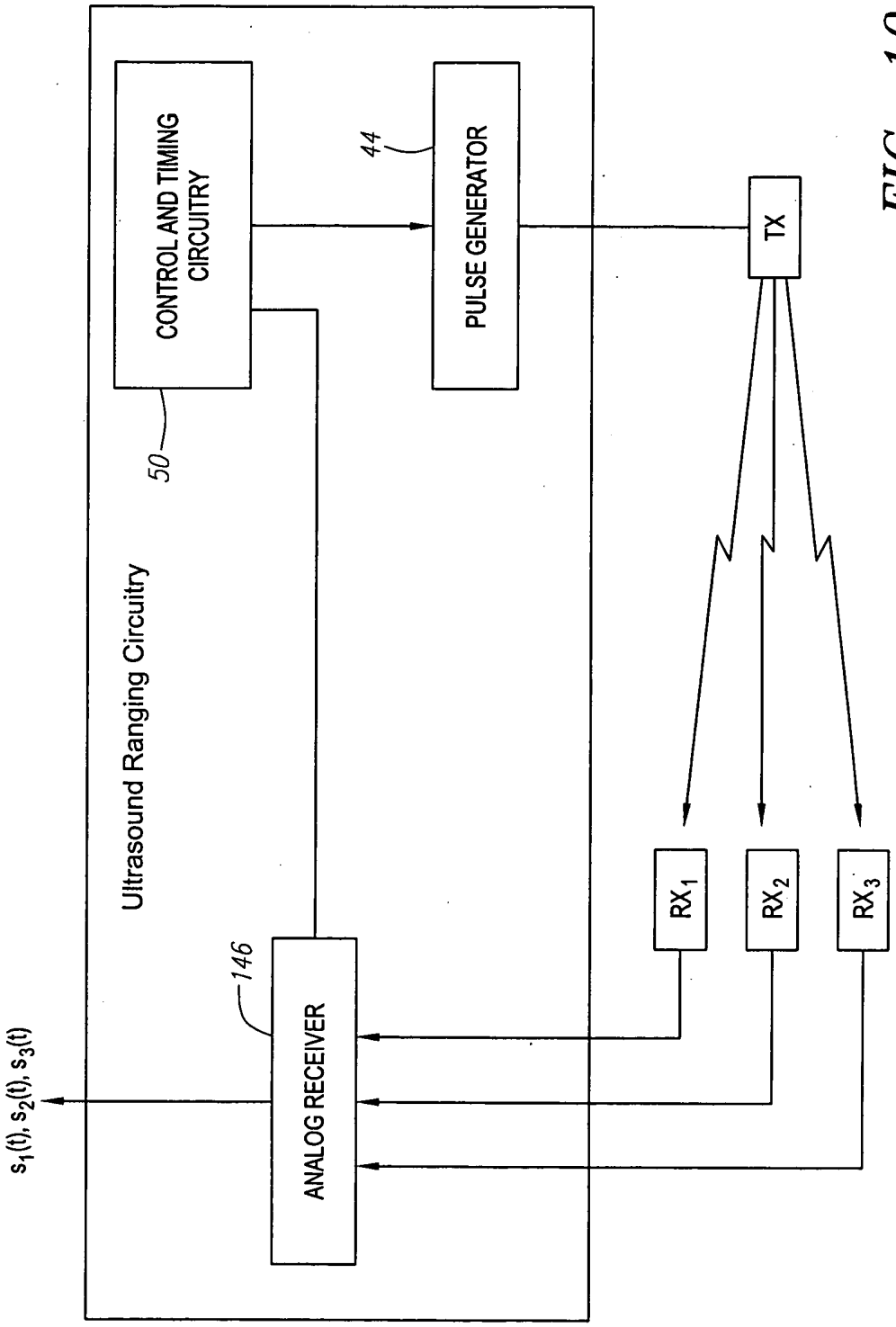

Ultrasound Ranging Circuitry
CONTROL AND TIMING CIRCUITRY
50
44
PULSE GENERATOR
TX
RX1
RX2
RX3
146
ANALOG RECEIVER
s1(t), s2(t), s3(t)

FIG. 10

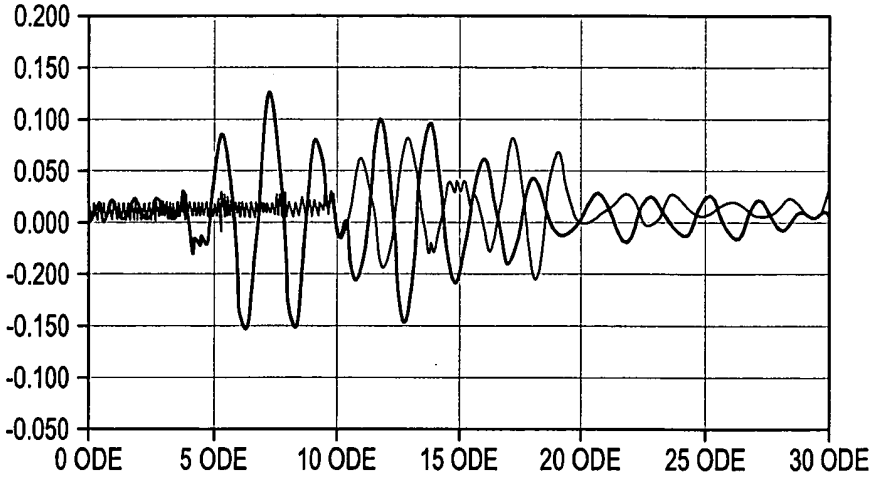

0.200
0.150
0.100
0.050
0.000
-0.200
-0.150
-0.100
-0.050
0 ODE
5 ODE
10 ODE
15 ODE
20 ODE
25 ODE
30 ODE

FIG. 11

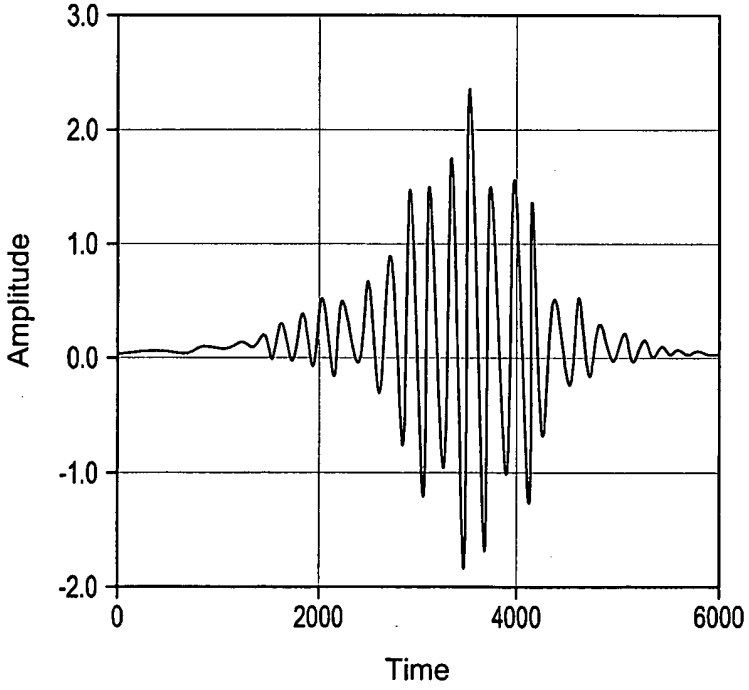

3.0
2.0
1.0
0.0
-1.0
-2.0
Amplitude
0
2000
4000
6000
Time

FIG. 12

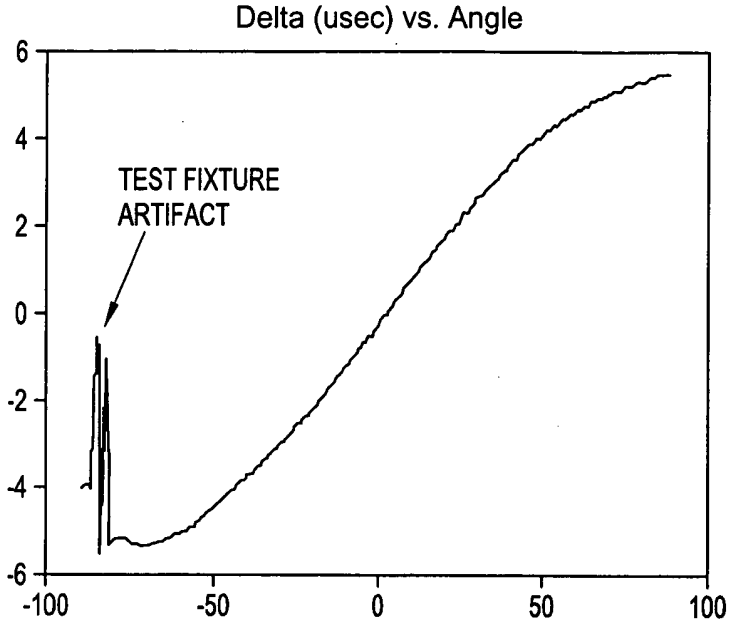

Delta (usec) vs. Angle
TEST FIXTURE
ARTIFACT
6
4
2
0
-2
-4
-6
-100
-50
0
50
100

FIG. 13

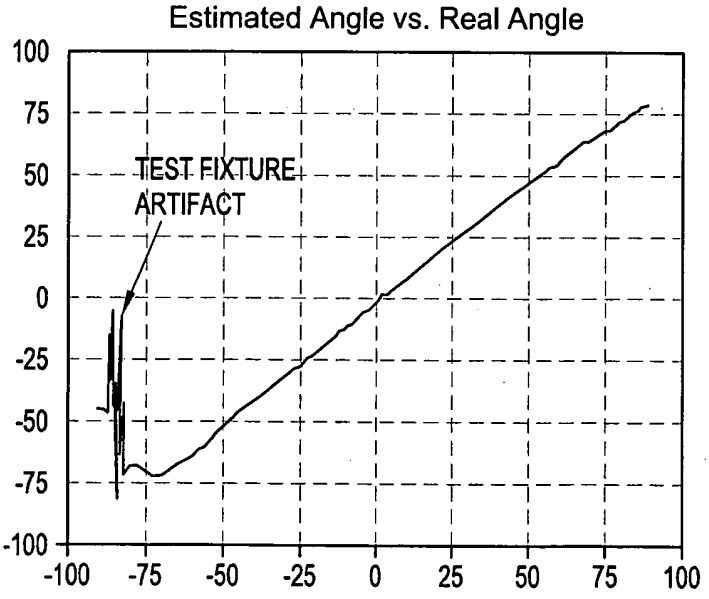

Estimated Angle vs. Real Angle
TEST FIXTURE
ARTIFACT
100
75
50
25
0
-25
-50
-75
-100
-100
-75
-50
-25
0
25
50
75
100

FIG. 14